

PROCESS TO CONTINUOUSLY PREPARE TWO OR MORE BASE OIL  
GRADES AND MIDDLE DISTILLATES

Field of invention

The invention relates to a process to continuously prepare two or more base oil grades and middle distillates.

5       Background of the invention

WO-A-0250213 describes a process wherein different base oil grades are made in a so-called blocked out mode. In this process a bottoms fraction of a fuels hydrocracking process, which thus also yields middle 10 distillates as products, is separated into various base oil precursor fractions. These fractions are subsequently catalytically dewaxed one after the other using a platinum-ZSM-5 based catalyst.

WO-A-9718278 discloses a process wherein up to 4 base 15 oil grades, e.g. a 60N, 100N and 150N, are prepared starting from the bottoms fraction of a fuels hydrocracker. In this process the bottoms fraction is fractionated in a vacuum distillation into 5 fractions of which the heavier 4 fractions are further processed to 20 different base oil grades by first performing a catalytic dewaxing followed by a hydrofinishing step.

WO-A-02/50213 discloses a so-called blocked-out process to prepare different base oil grades from the bottoms fraction of a fuels hydrocracking process.

25       A disadvantage of the above processes is that the process is not continuous. In other words the base oil grades are not made at the same time but sequential. This requires tankage for the intermediate products as obtained when the hydrocracker bottoms are fractionated 30 and are awaiting their turn to be catalytically dewaxed.

5 A further disadvantage are the mode switches which result in heating up of equipment and cooling of equipment causing erosion of equipment. The mode switches also result in intermediate off-spec product every time a new grade is being processed. These slops need to be reprocessed or disposed off which is disadvantageous.

10 EP-A-649896 discloses a process to prepare a residue comprising a base oil by means of a process involving a hydrotreating step and a hydrocracking step on a heavy petroleum feedstock. The hydroprocessing steps yield a product from which middle distillates and a bottoms fraction (residue) are obtained. This bottoms fraction is subsequently solvent dewaxed to a single base oil grade.

15 EP-A-0 272 729 discloses a process for the manufacture of lubricating base oils, wherein a flashed distillate produced via a residue conversion process is fed to a hydrocracking unit. The effluent from the hydrocracking unit is fed to a catalytic dewaxing unit and thereafter optionally the whole dewaxed stream is 20 subjected to a hydrotreatment.

25 WO-A-9723584 discloses a process wherein the bottoms fraction of a fuels hydrocracker is subjected to a catalytic dewaxing step. The dewaxed oil is partly recycled to the hydrocracking step and partly obtained as the lubricating base oil.

30 A disadvantage of the above process as described in WO-A-9723584 is that if more than one base oil grade is isolated from the dewaxed oil a large pour point distribution occurs. In other words the resulting lower viscous base oil grades will have a too low pour point. This pour point give away, or difference with the desired value, is indicative for yield loss of said lower viscous base oil grade.

35 One object of the present invention is to provide a process, which is capable of preparing two or more base

oil grades simultaneously and wherein their respective pour points are more close to the desired values.

It is another object of the present invention to provide an alternative process.

5 Summary of the invention

The following process achieves one or more of the above or other objects.

Process to prepare simultaneously two or more base oil grades and middle distillates from a de-asphalting oil or a vacuum distillate feed or their mixtures by 10 performing the following steps:

- (a) hydrocracking the feed, thereby obtaining an effluent;
- (b) distillation of the effluent as obtained in step (a) 15 into one or more middle distillates and a residue boiling substantially above 340 °C;
- (c) separating, by means of a further distillation step said residue into a light base oil precursor fraction and a heavy base oil precursor fraction;
- 20 (d) reducing the pour point of each separate base oil precursor fraction in two simultaneously and parallel operated catalytic dewaxing reactors obtaining a first and second dewaxed oil;
- (e) hydrotreating the first dewaxed oil as obtained when 25 dewaxing the heavy base oil precursor fraction in step (d);
- (f) isolating from the second dewaxed oil from the light base oil precursor fraction from step (d) and the hydrotreated oil from step (e) two or more base oil 30 grades.

Applicants found that when processing according to the invention it is possible to continuously prepare two or more base oil grades and at the same time reduce the hydrotreating capacity because only the heavier grades 35 which require further hydrotreating are subjected to said

5 step (e). Further any product give away in pour point may be avoided because the two parallel operated dewaxing reactors can be operated such that the pour point of the resulting low and high viscous base oil grades are close to the desired values. Any pour point give away is indicative for yield loss of the grade having the lower than desired pour point.

Detailed description of the invention.

10 The feed to step (a) may be any typical mineral crude derived feed to a hydrocracker. Such feedstocks may be the vacuum gas oil or heavier distillate fractions as obtained when distilling at near vacuum conditions the atmospheric residue of a crude mineral oil feedstock. The deasphalting oil as obtained when deasphalting the residue 15 as obtained in said vacuum distillation may also be used as feed. Light and heavy cycle oils as obtained in a fluid catalytic cracking process (FCC), thermally flashed distillate and aromatic rich extracts as for example obtained in solvent extraction process steps in traditional base oil processing may also be used as feed. 20 Mixtures of the above described feeds and optionally other hydrocarbon sources are also suitable as feedstocks. An optional alternative hydrocarbon source, which may be present in addition to the above feedstocks, 25 preferably in amounts of between 2 and 30 wt% of the feed to step (a), are the paraffin wax as obtained in a Fischer-Tropsch process. Preferably the feed to step (a) consists of a mineral crude derived feed.

30 Step (a) may be performed at a conversion level of between 15 and 90 wt%. The conversion is expressed in the weight percentage of the fraction in the feed which boils above 370 °C which are converted to products boiling below 370 °C. The main products boiling below 370 °C are naphtha, kerosene and gas oil. Examples of possible 35 hydrocracker processes suitable for performing step (a)

are described in EP-A-699225, EP-A-649896, WO-A-9718278, EP-A-705321, EP-A-994173 and US-A-4851109.

The operating conditions of a single step hydrocracking process include preferably a temperature in the range of from 350 to 450 °C, a hydrogen pressures in the range of from 9 to 200 MPa, more preferably above 11 MPa, a weight hourly space velocities (WHSV) in the range of from 0.1 to 10 kg of oil per liter of catalyst per hour (kg/l/hr), preferably from 0.2 to 5 kg/l/hr, more preferably from 0.5 to 3 kg/l/hr and hydrogen to oil ratios in the range of from 100 to 2,000 liters of hydrogen per liter of oil.

Preferably the hydrocracker is operated in two steps, consisting of a preliminary hydrotreating step followed by a hydrocracking step. In the hydrotreating step nitrogen and sulphur are significantly removed and aromatics are significantly saturated to naphthenes and part of the naphthenes are converted to paraffins by ring opening reactions. In order to improve the yield of the more viscous grade base oils the fuels-hydrocracker is more preferably operated by first (i) hydrotreating a hydrocarbon feed at a feed conversion, wherein the conversion, as defined above, of less than 30 wt% and preferably between 15 and 25 wt%, and (ii) hydrocracking the product of step (i) in the presence of a hydrocracking catalyst at such a conversion level that the overall conversion of step (i) and (ii) is between 15 and 90 wt% and preferably between 40 and 85 wt%.

The operating conditions of a hydrotreating step are preferably a temperature in the range of from 350 to 450 °C, a hydrogen pressures in the range of from 9 to 200 MPa, more preferably above 11 MPa, a weight hourly space velocities (WHSV) in the range of from 0.1 to 10 kg of oil per liter of catalyst per hour (kg/l/hr), preferably from 0.2 to 5 kg/l/hr, more preferably from

0.5 to 3 kg/l/hr and hydrogen to oil ratios in the range of from 100 to 2,000 liters of hydrogen per liter of oil.

The operating conditions of a hydrocracking step performed in combination with a hydrotreatings step are 5 preferably a temperature in the range of from 300 to 450 °C, a hydrogen pressures in the range of from 9 to 200 MPa, more preferably above 11 MPa, a weight hourly space velocities (WHSV) in the range of from 0.1 to 10 kg of oil per liter of catalyst per hour (kg/l/hr), 10 preferably from 0.2 to 5 kg/l/hr, more preferably from 0.5 to 3 kg/l/hr and hydrogen to oil ratios in the range of from 100 to 2,000 liters of hydrogen per liter of oil.

The residues as prepared by the processes as described above have a very low content of sulphur, 15 typically below 250 or even below 150 ppmw, and a very low content of nitrogen, typically below 30 ppmw. The residue is preferably a full range residue.

It has been found that by performing the combined hydrotreating and hydrocracking step as described above a residue is obtained which yields a high quantity of the 20 more viscous grade base oil, also referred to as medium machine oil grade, and of acceptable quality with respect to viscosity index. In addition a sufficient quantity of naphtha, kerosine and gas oils are obtained by this process. Thus a fuels hydrocracker process is obtained 25 wherein simultaneously products ranging from naphtha to gas oil and a residue is obtained, which residue has the potential to yield a medium machine oil base oil grade. The viscosity index of the resulting base oil grades is 30 suitably between 95 and 120, which is acceptable to yield base oils having a viscosity index according to the API Group II specifications.

It has been found that in the hydrotreating step (i) the viscosity index of the residue and the resulting base 35 oil grades increases with the conversion in said

hydrotreating step. By operating the hydrotreating step at high conversion levels of more than 30 wt% viscosity index values for the resulting base oils of well above 120 can be achieved. A disadvantage of such a high conversion in step (i) is however that the yield of medium machine oil fraction will be undesirably low. By performing step (i) at the above described conversion levels an API Group II medium machine oil grade base oil can be obtained in a desired quantity. The minimum conversion in step (i) will be determined by the desired viscosity index, of between 95 and 120, of the resulting base oil grades and the maximum conversion in step (i) is determined by the minimum acceptable yield of medium machine oil grade.

The preliminary hydrotreating step is typically performed using catalyst and conditions as for example described in the above-mentioned publications related to hydrocracking. Suitable hydrotreating catalysts generally comprise a metal hydrogenation component, suitably Group IVB or VIII metal, for example cobalt-molybdenum, nickel-molybdenum, on a porous support, for example silica-alumina or alumina. The hydrotreating catalysts suitably contains no zeolite material or a very low content of less than 1 wt%. Examples of suitable hydrotreating catalysts are the commercial ICR 106, ICR 120 of Chevron Research and Technology Co.; 244, 411, DN-120, DN-180, DN-190 and DN-200 of Criterion Catalyst Co.; TK-555 and TK-565 of Haldor Topsoe A/S; HC-k, HC-P, HC-R and HC-T of UOP; KF-742, KF-752, KF-846, KF-848 STARS and KF-849 of AKZO Nobel/Nippon Ketjen; and HR-438/448 of Procatalyse SA.

The hydrocracking step is preferably a catalyst comprising an acidic large pore size zeolite within a porous support material with an added metal hydrogenation/dehydrogenation function. The metal having

the hydrogenation/dehydrogenation function is preferably a Group VIII/Group VIB metal combination, for example nickel-molybdenum and nickel-tungsten. The support is preferably a porous support, for example silica-alumina and alumina. It has been found that a minimum amount of zeolite is advantageously present in the catalyst in order to obtain a high yield of medium machine oil fraction in the full range residue when performing the hydrocracker at the preferred conversion levels as explained above. Preferably more than 1 wt% of zeolite is present in the catalyst. Examples of suitable zeolites are zeolite X, Y, ZSM-3, ZSM-18, ZSM-20 and zeolite beta of which zeolite Y is most preferred. Examples of suitable hydrocracking catalysts are the commercial ICR 220 and ICR 142 of Chevron Research and Technology Co; Z-763, Z-863, Z-753, Z-703, Z-803, Z-733, Z-723, Z-673, Z-603 and Z-623 of Zeolist International; TK-931 of Haldor Topsoe A/S; DHC-32, DHC-41, HC-24, HC-26, HC-34 and HC-43 of UOP; KC2600/1, KC2602, KC2610, KC2702 and KC2710 of AKZO Nobel/Nippon Ketjen; and HYC 642 and HYC 652 of Procatalyse SA.

The effluent of the hydrocracker is separated into one or more of the above referred to fuels fractions and a residue. The residue, wherein the residue boils predominately above 340 °C, is used as feed to step (c). With boiling predominately above 340 °C is especially meant that more than 80 wt%, preferably more than 90 wt%, boils above 340 °C. Because a substantial fraction of the residue may boil in the gas oil range a considerable amount of gas oil is recovered after dewaxing having excellent cold flow properties. Preferably between 10 and 40 wt% of the dewaxed oil as obtained in this process boils in the heavy gas oil range being between from 350 to 400 °C. It should of course be understood that also lower boiling gas oil fractions are obtained in step (c).

5        The final boiling point of the residue will be partly determined by the final boiling point of the feed to step (a) and may be far greater than 700 °C up to values of which cannot be determined by means of the standard test methods.

10      Optionally part of the residue as obtained in step (b) may be recycled to step (a) as for example described in EP-A-0994173, which publication is incorporated by reference. Optionally the residue may be recycled to only the hydrocracking step of step (a) as for example described in EP-B-0699225, which publication is incorporated by reference. Preferably less than 15 wt% of the residue is recycled to step (a) and more preferably no residue is recycled to step (a). It has been found that API Group II base oils may be prepared having a good quality without having to perform such a recycle.

15      In step (c) the feed is separated by means of distillation into a light base oil precursor fraction and a heavy base oil precursor fraction and optionally a vacuum gas oil fraction. Preferably any vacuum gas oil is not separated from the light base oil precursor fraction but remains combined with said fraction in order to be dewaxed as well in step (d). The distillation is suitably performed at reduced pressures, more preferably the vacuum distillation is performed at a pressure of between 20 0.01 and 0.3 bara. Preferably the 10 wt% recovery point 25 of the heavy base oil precursor fraction as obtained in step (c) is preferably between 420 and 550 °C and more preferably between 440 and 520 °C.

30      The feed to step (d) will comprise of the base oil precursor fractions as obtained in step (c). Optionally some partly isomerised paraffin wax boiling in the heavy or light base oil precursor fractions boiling range may 35 be present in a mixture with said light base oil

5 precursor fraction. This paraffin product is also referred to as waxy raffinate, as obtained in a Fischer-Tropsch or Gas-to-Liquids Process. Such a waxy Raffinate may be prepared according the process as described in  
WO-02070630, which publication is incorporated herein by reference.

10 Optionally a noble metal guard bed may be positioned just upstream the dewaxing catalyst bed in the dewaxing reactor in step (d) in order to decrease the level of sulphur and especially nitrogen compounds. Such a guard bed may be especially advantageous in the dewaxing reactor in which the heavy base oil precursor fraction is processed. An example of such a process is described in  
15 WO-A-9802503, which reference is hereby incorporated by reference.

20 The catalytic dewaxing step in the parallel operated reactors in step (d) can be performed by any process wherein in the presence of a catalyst and hydrogen the pour point of the base oil fraction is reduced. Suitably the pour point is reduced by at least 10 °C and more suitably by at least 20 °C. Suitable dewaxing catalysts are heterogeneous catalysts comprising a molecular sieve and optionally in combination with a metal having a hydrogenation function, such as the Group VIII metals.  
25 Molecular sieves, and more suitably intermediate pore size zeolites, have shown a good catalytic ability to reduce the pour point of a base oil fraction under catalytic dewaxing conditions. Preferably the intermediate pore size zeolites have a pore diameter of  
30 between 0.35 and 0.8 nm. Suitable intermediate pore size zeolites are ZSM-5, ZSM-12, ZSM-22, ZSM-23, SSZ-32, ZSM-35 and ZSM-48. Another preferred group of molecular sieves are the silica-aluminaphosphate (SAPO) materials of which SAPO-11 is most preferred as for example  
35 described in US-A-4859311. ZSM-5 may optionally be used

in its HZSM-5 form in the absence of any Group VIII metal. The other molecular sieves are preferably used in combination with an added Group VIII metal. Suitable Group VIII metals are nickel, cobalt, platinum and palladium. Examples of possible combinations are 5 Ni/ZSM-5, Pt/ZSM-23, Pd/ZSM-23, Pt/ZSM-48 and Pt/SAPO-11. Further details and examples of suitable molecular sieves and dewaxing conditions are for example described in WO-A-9718278, US-A-5053373, US-A-5252527 and 10 US-A-4574043.

The process according the present invention makes it possible to continuously prepare base oils using dewaxing catalysts, which show a relatively large pour point distribution in case the full range residue is processed 15 as for example described in WO-A-9723584. By making use of the present invention such a large pour point distribution can be avoided while using such relatively poor performing dewaxing catalysts. An example of such a catalyst that shows a relatively large pour point distribution is the ZSM-5 based catalyst. Thus ZSM-5 based catalysts may be advantageously applied in the 20 present invention. The process also makes it possible to use different dewaxing catalysts in the parallel-operated reactors, which catalyst can be more tailored to their 25 respective feeds.

The dewaxing catalyst suitably also comprises a binder. The binder can be a synthetic or naturally occurring (inorganic) substance, for example clay, silica and/or metal oxides. Natural occurring clays are for 30 example of the montmorillonite and kaolin families. The binder is preferably a porous binder material, for example a refractory oxide of which examples are: alumina, silica-alumina, silica-magnesia, silica-zirconia, silica-thoria, silica-beryllia, silica-titania 35 as well as ternary compositions for example silica-

5 alumina-thoria, silica-alumina-zirconia, silica-alumina-magnesia and silica-magnesia-zirconia. More preferably a low acidity refractory oxide binder material which is essentially free of alumina is used. Examples of these binder materials are silica, zirconia, titanium dioxide, germanium dioxide, boria and mixtures of two or more of these of which examples are listed above. The most preferred binder is silica.

10 A preferred class of dewaxing catalysts comprise intermediate zeolite crystallites as described above and a low acidity refractory oxide binder material which is essentially free of alumina as described above, wherein the surface of the aluminosilicate zeolite crystallites has been modified by subjecting the aluminosilicate 15 zeolite crystallites to a surface dealumination treatment. A preferred dealumination treatment is by contacting an extrudate of the binder and the zeolite with an aqueous solution of a fluorosilicate salt as described in for example US-A-5157191. Examples of 20 suitable dewaxing catalysts as described above a silica bound and dealuminated Pt/ZSM-5 and silica bound and dealuminated Pt/ZSM-23, silica bound and dealuminated Pt/ZSM-12 and silica bound and dealuminated Pt/ZSM-22, as for example described in WO-A-200029511 and 25 EP-B-832171.

30 Catalytic dewaxing conditions are known in the art and typically involve operating temperatures in the range of from 200 to 500 °C, suitably from 250 to 400 °C, hydrogen pressures in the range of from 10 to 200 bar, weight hourly space velocities (WHSV) in the range of 35 from 0.1 to 10 kg of oil per litre of catalyst per hour (kg/l/hr), suitably from 0.2 to 5 kg/l/hr, more suitably from 0.5 to 4 kg/l/hr and hydrogen to oil ratios in the range of from 100 to 2,000 litres of hydrogen per litre of oil. The weight hourly space velocities (WHSV) in the

5 catalytic dewaxing step in which the light base oil precursor fraction is processed is preferably higher than the WHSV in the dewaxing step of the heavy base oil precursor fraction. More preferably the WHSV in the dewaxing step of the light base oil precursor fraction is between 1 and 5 kg/l/hr.

10 If the dewaxing step and the hydrofinishing step are performed in cascade the pressure level in both steps is suitably of the same order. Because higher pressures are preferred in the hydrofinishing step in order to obtain a base oil having the desired properties the dewaxing step is suitably also performed at these higher pressures, even though a more selective dewaxing could have been achieved at lower pressures. If no hydrofinishing step is 15 required, as has been found to be the case for the dewaxed oil obtained from the light base oil precursor fraction to prepare for example the spindle oil base oil grade, a lower catalytic dewaxing pressure can advantageously be applied. Suitable pressures are from 15 20 to 100 bar and more suitably from 1.5 to 6.5 MPa.

25 The hydrotreating step (e) also referred to as a hydrofinishing step is to improve the quality of the dewaxed fraction. In this step lube range olefins are saturated, heteroatoms and colour bodies are removed and if the pressure is high enough residual aromatics are saturated. Preferably the conditions are so chosen to obtain a base oil grade comprising more than 95 wt% saturates and more preferably such that a base oil is obtained comprising more than 98 wt% saturates. The 30 hydrofinishing step is suitably carried out in cascade with the dewaxing step of the heavy base oil precursor fraction.

35 The hydrofinishing step is suitable carried out at a temperature between 230 and 380 °C, a total pressure of between 1 to 25 MPa and preferably above 10 MPa and more

preferably between 12 and 25 MPa. The WHSV (Weight hourly space velocity) ranges from 0.3 to 10 kg of oil per litre of catalyst per hour (kg/l.h).

5 The hydrofinishing or hydrogenation catalyst is suitably a supported catalyst comprising a dispersed Group VIII metal. Possible Group VIII metals are cobalt, nickel, palladium and platinum. Cobalt and nickel containing catalysts may also comprise a Group VIB metal, suitably molybdenum and tungsten.

10 Suitable carrier or support materials are low acidity amorphous refractory oxides. Examples of suitable amorphous refractory oxides include inorganic oxides, such as alumina, silica, titania, zirconia, boria, silica-alumina, fluorided alumina, fluorided silica-alumina and mixtures of two or more of these.

15 Suitable hydrogenation catalysts include those catalysts comprising as one or more of nickel (Ni) and cobalt (Co) in an amount of from 1 to 25 percent by weight (wt%), preferably 2 to 15 wt%, calculated as element relative to total weight of catalyst and as the Group VIB metal component one or more of in an amount of from 5 to 30 wt%, preferably 10 to 25 wt%, calculated as element relative to total weight of catalyst. Examples of suitable nickel-molybdenum containing catalyst are KF-847 and KF-8010 (AKZO Nobel) M-8-24 and M-8-25 (BASF), and C-424, DN-190, HDS-3 and HDS-4 (Criterion). Examples of suitable nickel-tungsten containing catalysts are NI-4342 and NI-4352 (Engelhard), C-454 (Criterion). Examples of suitable cobalt-molybdenum containing catalysts are KF-330 (AKZO-Nobel), HDS-22 (Criterion) and HPC-601 (Engelhard).

20 30 35 For hydrocracked feeds containing low amount of sulphur, as in the present invention, preferably platinum containing and more preferably platinum and palladium containing catalysts are used. The total amount of these

5 noble Group VIII metal component(s) present on the catalyst is suitably from 0.1 to 10 wt%, preferably 0.2 to 5 wt%, which weight percentage indicates the amount of metal (calculated as element) relative to total weight of catalyst.

10 Preferred supports for these palladium and/or platinum containing catalysts are amorphous silica-alumina, whereby more preferably the silica-alumina comprises from 2 to 75 wt% of alumina. Examples of suitable silica-alumina carriers are disclosed in WO-A-9410263. A preferred catalyst comprises an alloy of palladium and platinum preferably supported on an amorphous silica-alumina carrier of which the commercially available catalysts C-624 and C-654 of

15 Criterion Catalyst Company (Houston, TX) are examples.

20 In step (f) the two or more base oil grades and optionally a gas oil comprising fraction are isolated from the light base oil precursor fraction from step (d) and the hydrotreated oil from step (e). The base oils and the optional gas oil comprising fraction are preferably isolated from a mixture of these streams. This is advantageous because any compounds present in the heavy base oil precursor fraction which are converted in step (d) to a boiling range of a lighter base oil grade will 25 then contribute to the base oil yield of said lighter base oil grade.

30 Because the gas oil product as obtained as described above has been subjected to a catalytic dewaxing step a fuel product is obtained having a very low content of aromatics and sulphur in combination with excellent low temperature properties. Especially a gas oil may be obtained in step (d) having a very low sulphur content of below 10 ppm, a low aromatics content of below 35 0.1 mmol/100 grams, excellent cold flow properties like a pour point of below -30 °C and a cold filter plugging

point of below -30 °C. The gas oil also has excellent lubricity properties. This makes such a gas oil especially an excellent refinery blending component to blend low sulphur gas oil. The gas oil may also be used 5 as a drilling mud fluid component, an electrical oil, a cutting oil, an aluminium rolling oil or as a fruit spray oil.

Step (f) may be performed by withdrawing products along a distillation column operating at near vacuum 10 conditions as well known to the skilled person.

Preferably so-called side-strippers are used to isolate the base oil products. Intermediate fractions may also be withdrawn in order to meet the volatility requirements of the desired base oil grades. Suitably before the above 15 low pressure distillation step a higher pressure distillation step, at about atmospheric conditions, may be performed in order to separate any naphtha, kerosene and gas oil fractions, separately or as a mixture, from the dewaxed oil. These middle distillate fractions may be used as such or recycled to step (b) such that a mixture 20 of dewaxed and hydrocracked middle distillate fuels are obtained. Thus in step (f) gaseous tops, a liquid tops comprising the above middle distillates, and various base oil grades, as for example a spindle oil, a light machine 25 oil and a medium machine oil are obtained in the final distillation of step (f).

In the context of the present invention terms as spindle oil, light machine oil and medium machine oil 30 will refer to base oil grades having an increasing kinematic viscosity at 100 °C and wherein the spindle oil additionally has a maximum volatility specification. The advantages of the present process are achieved for any group of base oils having such different viscosity requirement and volatility specification. Preferably a 35 spindle oil is a light base oil product having a

kinematic viscosity at 100 °C of below 5.5 cSt and preferably above 3.5. The spindle oil can have either a Noack volatility, as determined by the CEC L-40-T87 method, of preferably below 20% and more preferably below 5 18% or a flash point, as measured according to ASTM D93, of above 180 °C. Preferably the light machine oil has a kinematic viscosity at 100 °C of below 9 cSt and preferably above 6.5 cSt and more preferably between 8 and 9 cSt. Preferably the medium machine oil has a 10 kinematic viscosity at 100 °C of below 14 cSt and preferably above 10 cSt and more preferably between 11 and 13 cSt. The corresponding base oil grade can have a viscosity index of between 95 and 120. Gas oil as obtained in the process according the invention will boil 15 typically from 150 and 370 °C and will have a T90wt% of between 340-400 °C.

The process of the present invention is further illustrated by Figure 1. Figure 1 shows a hydrocarbon feed line (1) to hydrocracker (2). The hydrocrakate (3) 20 is separated into a naphtha (5), kerosene (6), a gas oil (7) a bottoms fraction (8) in distillation column (4). The bottoms fraction or full range residue (4) is split into a light base oil precursor fraction (10) and a heavy base oil precursor fraction (11) in distillation column (9). The light base oil precursor fraction (10) is dewaxed in dewaxing 25 reactor (12) yielding a dewaxed oil (16; "second dewaxed oil"). The heavy base oil precursor fraction (11) is dewaxed in dewaxing reactor (13). The dewaxed oil (15; "first dewaxed oil") is hydrotreated in hydrofinishing 30 reactor (14) yielding a dewaxed and hydrotreated oil (17). Oils (16) and (17) are combined. Hydrogen (19) is separated in separator (18) and recycled to the dewaxing units (12) and (13) after adding fresh hydrogen 35 (20). The oil (21) is subsequently separated into a low

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boiling fraction (26), a spindle oil grade (23), a light machine oil grade (24) and a medium machine oil grade (25) is distillation column (22). The fraction (26) is recycled to the work-up section of the hydrocracker (2) in order to isolate the valuable fuels fractions.